

the simple reflex we are considering. The coordination goes much farther than we have yet assumed. The musculature of the limb is an instance of that kind of musculature which obtains where parts are adapted to move, not in one direction only or one way only, but in many. The limb has to do many different things. It has, according to circumstances, to bend or to straighten, to turn inwards at one time, at another to turn outwards, to move this finger or move that. Its musculature is therefore split up into many different muscles—some doing this, some doing that. Hence it comes that in the limb are muscles which when they contract do with the limb exactly opposite things. Thus we find a set of muscles which bend the knee, and another which straighten the knee; so, similarly, at hip and ankle, at elbow, shoulder, and wrist. These muscles of opposed action are called antagonists. Now in the flexion reflex—the reflex we are considering—when the reflex bends the knee by causing the flexor muscles to contract, what happens with regard to the muscles which straighten the knee? Do the opponents, the muscles which straighten the knee, contract, or does the reflex nervous influence leave these muscles untouched? It used to be taught that the muscles which straighten the knee, the extensor muscles, contract, and by their contraction exert a moderating influence on the muscles which execute the flexion. That was the anatomical speculation deduced from simple dissection of the musculature of the dead limb. Experiment with the living limb teaches that nature does not expend her muscular energy in using the power of one muscle simply to curb the power of another. When the knee is bent the reflex act does not hamper the working of the flexor muscles by causing a contraction of the extensors also. Nor does it simply leave the extensors out of account. No; it causes them to relax and lengthen at the same time as it causes the flexor muscles to contract and shorten. This it does by reflex *inhibition*; and it proportions the grade of this relaxation exactly to the grade of contraction of the opponent muscles.

The inhibition acts, not on the muscle directly, but on the motor nerve-cells innervating the muscle. These nerve-cells are long filaments; one end of each lies in the muscle, the other in the spinal cord. The reflex inhibition is exercised upon them at the end which lies in the spinal cord. In the reflex we are considering, the reflex action, besides *exciting* the motor nerve-cells of the three muscle groups—flexors, abductors, and internal rotators—before mentioned, *inhibits* the motor nerve-cells of three muscle groups antagonistic to those, namely, the extensors, the abductors, and external rotators. We see, therefore, that in even the simple reflex lifting of the foot, almost every one of the many muscles composing the whole musculature of the limb receives from the nervous system a controlling influence, either of excitation to contract or of inhibition which relaxes contraction; and all this in result of a simple touch of the skin of the foot. The reaction typifies in a simple manner the action of the nervous system to knit the heterogeneous powers of the body together into one harmonious whole.

Thus we see that in these actions when one group of muscles contracts the group antagonistic to it relaxes. This is a fundamental part of the coordination of the act, and its discovery throws a welcome light on the nature of certain maladies. Were the antagonistic group to contract at the same time as the protagonist, the desired movement would not result. The movement which then ensued would depend on which of the two muscle groups were the stronger, the protagonist or the antagonist. The alkaloid strychnine and the poison produced by the bacilli which cause the malady called "lock-jaw" possess the power of destroying reflex inhibition. What the intricate nature of the process of this inhibition is we do not yet know, but it seems to be the exact converse of the process of excitation, the nature of which is also unknown. Strychnine and tetanus-toxin change the process of inhibition into its converse, namely, excitation. If a minute dose of strychnine be administered, the reflex which, as we saw, causes the limb to bend, now causes the limb to straighten instead. This is because the extensors, when the flexors contract, instead of being relaxed by inhibition, are excited to contraction, and being more powerful than

the flexors move the limb in exactly the opposite direction to that in which it should move in this reflex action. Similarly with the toxin of "lock-jaw." The muscles which close the jaws are much more powerful than those which open them. In the normal act of opening the mouth the relatively feeble opening muscles contract, and the powerful closing muscles are simultaneously relaxed by reflex inhibition. But in an animal or man poisoned with this toxin the normal inhibition of the closing muscles is changed to the exactly opposite process of excitation, so that their contraction results. Against the power of these strong closing muscles the contraction of the weak opening muscles can effect little. Each time, therefore, that the sufferer tries to open his jaws to take food or speak, he clenches his jaws instead of opening them—experiencing a torture which, although unaccompanied by physical pain, is inexpressibly distressing; and the disorder leads to death from inanition.

But to return to the reflex lifting of the leg, whence we set out. It was mentioned that in this reflex the limb was not merely lifted, but was slightly rotated inwards at the hip, and that the thigh was slightly abducted, that is to say, drawn sideways, separating it more from the fellow-limb of the opposite. These accessory movements have a significance coinciding with much other evidence into which we have not time to enter now. They, together with other evidence, show that this lifting of the leg, so easily produced reflexly, is nothing more nor less than the first movement of the taking of a step. In fact, in our rough and imperfect analysis of this little movement, we have been examining part of the great and extraordinarily complex and perfect act which is called walking—or more technically, so as to include the cognate acts of trotting and running—locomotion. A little reflection will suffice to assure you that included in the action of locomotion is also that of standing. We are apt to forget that the muscles have a static as well as a kinetic action—that they are the instruments of maintaining position, as well as of the execution of movements. Directly we begin to analyse locomotion we see that its basis, as it were, is the position of standing, upon which movements of stepping are, as it were, grafted. Not much is known as yet of how animals and ourselves stand, walk, and run. In these acts, probably, every skeletal muscle in the whole body is concerned. Rheumatism can make us aware of that. A little receptor organ in the ear is a great factor in the whole matter. But of this we may be sure, that foremost in its factors are reflex actions of the limbs. Great economic questions are involved in this unravelling of the act of locomotion—all beasts of draught and burden are chiefly useful to us because they can stand, and walk, and run. We can only employ their powers to full advantage and with due regard to them as they unfold these powers when we shall have learnt something of the way in which these movements are conducted and performed.

The crude and imperfect analysis which I have attempted to outline concerned but *one phase* of the step of a *single* limb. In the complete act the other limbs will at the same time be executing other phases of the whole cyclic reflex. The neck and trunk are also involved; so, likewise, the head itself. Our imperfect analysis threw sidelights on the nature of the mischief wrought by strychnine-poisoning and the malady "lock-jaw." Interesting and useful though these sidelights may be, more really interesting and valuable would be any light which such analysis, crude as it is, could throw on that great normal process of everyday health, animal (including human) locomotion. Analysis of the reflex movement in unconscious animals seems at the present time the only way by which such knowledge can be gained.

#### UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—Lord Rayleigh was on April 10 unanimously elected Chancellor of the University in succession to the late Duke of Devonshire. It is expected that the inauguration and the installation of the new Chancellor will take place during the May term.

EDINBURGH.—At the spring graduation ceremony on April 10, the honorary degree of Doctor of Laws was conferred upon several guests in recognition of scientific work. Sir Ludovic Grant, dean of the faculty of law, in presenting these recipients of the degree, made the following references to their achievements in the field of science:—

DR. J. O. AFFLECK.—Whether regard be had to Dr. Affleck's work as a teacher, or to his scientific contributions to medical literature, or to his eminence as a physician and his services in the practice of his profession, he is equally deserving of recognition at the hands of his old Alma Mater. Almost from the time that he graduated, Dr. Affleck has been an indefatigable writer. Indeed, the great bulk of the medical articles in the ninth edition of the "Encyclopædia Britannica" are from his pen. These, and his other papers, form together a veritable storehouse of scientific information.

DR. RICHARD CATON, Lord Mayor of Liverpool.—Dr. Caton was one of the band of devoted labourers whose strenuous exertions were instrumental in calling into existence the University of Liverpool, and he himself discharged the duties of professor of physiology for many years with conspicuous success. With his scientific attainments Dr. Caton combines the accomplishments of the scholar and the zest of the archaeologist. His lectures—embodying the fruits of visits to Greece and the Greek colonies—on the Greek and Egyptian gods of medicine throw a flood of light on the medical and sanitary aspects of the ancient world.

SIR NORMAN LOCKYER, K.C.B., F.R.S.—The fairy-book of science contains no more fascinating and marvellous pages than those contributed by the illustrious astronomer whose name has been so long a household word amongst us. It is to his spectroscopic researches that the present generation is largely indebted for its knowledge of the material constituents of the sun and of the stars. He it is who, simultaneously with the French astronomer Janssen, devised a means of studying the luminous atmosphere surrounding the sun, and those gigantic flames which previously could only be observed in the brief moments of a solar eclipse. He it is who first detected helium in the sun before this element had been discovered on the earth, while his investigations into the sun's spots and corona are of the highest importance in solar physics. It is worthy of mention that he has acted as the leader of more eclipse expeditions than any contemporary astronomer. The stars, too, have yielded to him their secrets not less obediently than the sun. By means of the comparative study of stellar spectra, he has drawn up a classification of the celestial bodies according to their temperatures and the order of their evolution, which must be reckoned as not the least noteworthy of the achievements of modern science. The great subject of "orientation" has also engaged Sir Norman Lockyer's attention. He has examined the monuments at Stonehenge and elsewhere, in their relation to astronomical phenomena, a work which is of great value as serving to fix the dates of their erection. The cause of scientific education generally has had no more ardent and eloquent advocate than Sir Norman Lockyer, and, as editor of NATURE and as founder of the British Science Guild, he has done as much as any man living for the diffusion throughout the country of the scientific spirit. The University is sensible that it is doing honour to itself in adding Sir Norman Lockyer's name to its roll of honorary graduates.

M. E. C. M. SENART, Chevalier de la Légion d'Honneur, Membre de l'Institut, Paris.—The literature of ancient India has been handled in modern Europe by no scholar of more exclusive erudition or more splendid attainments than by M. Senart. He first attracted the attention of the learned world by the publication, some thirty years ago, of his "Essay on the Legend of Buddha." Then followed the volumes on the "Inscriptions of Asoka," and a highly popular and instructive work on the Indian castes. Of his subsequent writings, none better exemplifies the remarkable range and accuracy of his scholarship than his edition of the famous Kharoshthi MS. of the Dhammapada, which was recovered from Central Asia by a French mission, while his monumental translation of the Mahavastu is sufficient by itself to place him in the highest

rank of philologists. His long series of publications, viewed as a whole, possess an importance which cannot easily be exaggerated, alike from the point of view of history, of philology, and of archaeology. M. Senart's achievements have received honorary recognition throughout the civilised world, and it is gratifying to relate that his influence has been instrumental in raising up in France a distinguished school of Orientalists, who, it may be hoped, will continue to carry on his work.

The degree was also conferred *in absentia* on RAMKRISHNA GOPAL BHANDARKAR, C.I.E., lately professor of Oriental languages, Deccan College, Poona. Prof. Bhandarkar is famed as a Sanskritist throughout the length and breadth of British India. His learned labours have extended over many years, and have been productive of a rich and valuable harvest of exegetical editions of Sanskrit works. These are chiefly remarkable in that they exhibit all that is best in the methods of interpretation traditional in India in combination with the critical scholarship of modern times. Prof. Bhandarkar has also devoted himself to the study of history and antiquities. He is the author of an admirable "History of the Deccan" and of numerous archaeological essays.

MANCHESTER.—The University kite station at Glossop Moor has now been equipped with a plant for the generation of hydrogen gas for use in work with captive and free balloons. Captain Ley has taken up residence on the moor in order to continue and extend his investigations for the study of the higher air currents by means of free balloons.

IN the new Ministry formed by Mr. Asquith in consequence of the retirement of Sir Henry Campbell-Bannerman from the office of Prime Minister, Mr. W. Runciman has succeeded Mr. R. McKenna as President of the Board of Education, and Mr. McKinnon Wood has succeeded Mr. T. Lough as Parliamentary Secretary to the Board.

TO the April number of *Science Progress* Prof. H. E. Armstrong contributes a vigorous article on the reform of the medical curriculum, in which he replies to Dr. Wade's remarks on a previous paper dealing with the same subject. The article covers a wide field, and is by no means confined to the question of medical education, as it deals with the broader issue of university education in general. In particular, the position of affairs within the University of London—the opposition existing between the external graduates and the internal schools, which has culminated in the formation of two representative bodies, the Graduates' Union and the Graduates' Association—calls for comment. A strong plea is urged for extending the internal system so as to allow each of the larger colleges to organise its own scheme of education for the final degrees according to the particular work it has to accomplish, without being hampered by external control through examination. Such a scheme is considered as by no means likely to lower the standard of the degree, but to tend in the opposite direction by making the education imparted more real and effective.

SIR WILLIAM H. PREECE, K.C.B., F.R.S., read a paper on technical education in America before the Royal Society of Arts on April 8. Referring to the munificent gifts made by American millionaires to assist educational development in the States, he directed attention to the fact that the distribution of wealth is much a matter of fashion. In 1906, in London alone more than ten millions sterling were bequeathed for various purposes, but of this only £123,778l. was allocated to education. The total amount bequeathed over the whole country must have exceeded fifty millions sterling, and of this probably only 1 per cent. was devoted to education. Speaking of American employers of industry, it was pointed out in the paper that they fully recognise the advantage of technical attainments in their employees, they encourage research, they equip their own laboratories, and they support college and university by financial help, and by the gift of machinery. In America, said Sir William Preece towards the close of his remarks, all are working on fixed methodical lines, and gradually a national coordinated system will be evolved which will make the United States

the best secularly educated country in the world, and their education policy thoroughly organised.

AN interesting comparison of examination statistics in 1906 with those in 1899 is made by Mr. G. F. Daniell in *The School World* for April. Dealing with the results of the matriculation examination of the London University, the article shows that, whereas in 1899, out of 1250 candidates, 842 selected a language and 402 a science "option," 3140 chose a linguistic and 2962 a scientific subject out of a total of 3253 in 1906. In the senior local examinations held by the Cambridge University, the stunted condition of the scientific side shown by the 1899 statistics gives place in 1906 to a more reasonable balance of science and the humanities, and, in the aggregate, the statistics of the junior examination show that science subjects are now receiving fair attention in secondary schools in general. Apparently, however, this cannot be said of the great public schools. Referring to the statistics published by the Oxford and Cambridge Schools' Examination Board, which examines pupils from public and high schools, Mr. Daniell remarks that out of 1027 candidates for the lower certificate of this Board, a total of thirty-four passes in the first class was obtained in the science subjects—of these thirty-four, no fewer than half were in botany, the successful candidates being mostly girls. Among some 2200 candidates for the higher certificate, eighty-three distinctions were obtained in science. It is justly pointed out that "this grudging admission of the claims of experimental science does not satisfy anyone who has realised the importance of educating the nation, especially the upper and middle classes, so that the future may find us not wanting in men of scientific intelligence."

## SOCIETIES AND ACADEMIES.

### LONDON.

**Royal Society, February 14, 1907.**—"The Thermomagnetic Analysis of Meteoric and Artificial Nickel-iron Alloys." By S. W. J. **Smith**. Communicated by Sir A. W. Rücker, F.R.S.

As the result of purely magnetic researches, the author comes to the conclusion that a typical octahedral meteorite (containing about 7 per cent. Ni and about 93 per cent. Fe, and exhibiting very regular Widmanstätten figures) consists mainly of an alloy of the two constituents containing about 6½ per cent. Ni. This alloy is kamacite. The thin intervening bands of more nickeliferous material (taenite) are shown in the same way to contain about 27 per cent. Ni, but, further, to be a mixture of nickel-rich and nickel-poorer constituents.

The view most commonly accepted hitherto, as the result of many careful chemical analyses, has been that taenite contains at least 36 per cent. Ni. A critical examination of these analyses shows, however, that they are in accord with the more certain conclusion derived from thermomagnetic data.

In the investigation of a problem of this kind chemical methods lead to ambiguous results, because it is impossible to isolate (from a material like meteoric iron) the secondary constituent (taenite) chemically without fear of partial solution. On the other hand, the taenite can be studied *in situ* by means of the change of its magnetic properties with temperature, because these properties vary in a markedly different way from those of the main constituent kamacite. Thus it can be shown that its properties correspond with those of the artificial 27 per cent. alloy, just as those of the kamacite correspond with those of the artificial 6½ per cent. alloy.

The inference from the experiments that taenite is a eutectic mixture (of coarser structure originally than the artificial 27 per cent. alloy, which is proved also to be a mixture) is shown to be in accord with all that is known concerning nickel-iron alloys, and to afford an adequate conception of the way in which the characteristic structure of meteoric iron has arisen.

The behaviour of "irreversible" nickel-iron alloys during changes of temperature is shown also to be closely

analogous to the behaviour of the metastable and labile fluid solutions studied by Prof. Miers.

An explanation is given of the important fact that an artificial nickel-iron alloy containing about 27 per cent. Ni is a "magnetic invar," of which the magnetic quality remains practically constant over a range of about 300° C. after the alloy has been cooled to the temperature of liquid air.

Further development of the thermomagnetic method is to be looked for in cases in which chemical and micrographic methods either fail to remove ambiguity or are inapplicable; meanwhile, if the interpretation of the thermomagnetic data considered is held to be established, a good many doubtful points in the relationship between iron and nickel in their alloys have been made clear.

• January 23, 1908.—"Dietetics in Tuberculosis: Principles and Economics." By Dr. N. D. **Bardewell** and J. E. **Chapman**. Communicated by Sir T. Clifford Allbutt, K.C.B., F.R.S.

February 13.—"The Decomposition of Ozone by Heat." By Prof. E. P. **Perman** and R. H. **Greaves**. Communicated by Principal E. H. Griffiths, F.R.S.

The rate of decomposition of ozone has been measured under various conditions, with the following results:—

- (1) In a glass vessel the reaction is approximately of the second order.
- (2) The relation between the rate of decomposition and temperature may be expressed by the formula  $\log k = a + bt$ .
- (3) The rate of decomposition is very largely influenced by the extent of the surface with which the ozone is in contact.
- (4) The reaction is of the first order when the ozone is in contact with a porous substance (clay-pipe stems) or some oxides.
- (5) Metallic surfaces have but little effect on the decomposition.
- (6) Water vapour accelerates the decomposition, and the acceleration is proportional to the amount present.
- (7) Nitric oxide greatly accelerates the decomposition.
- (8) The rate of decomposition is a linear function of the oxygen pressure. A greater effect is produced by diluting with nitrogen than by simply reducing the pressure of the oxygen.
- (9) At 100° the reaction appears to be very slightly reversible.
- (10) Finally, the decomposition appears to take place mainly (if not entirely) at the surfaces with which the ozone is in contact, and pressure measurements give no indication of the number of molecules reacting.

**Mineralogical Society, March 17.**—Prof. H. A. Miers, F.R.S., president, in the chair.—The occurrence of metamorphic minerals in calcareous rocks in the Bodmin and Camelford areas: G. **Barrow** and H. H. **Thomas**. The pneumatolytic action is not contemporaneous with the thermo-metamorphism produced by granite intrusions; the gaseous intrusions are later, and often produce their greatest effect beyond the zone of "contact action." The species of mineral produced depends on the nature of the rock penetrated by the gases. In killas, tourmaline is commonly produced, but in calcareous rocks, axinite and a variety of other minerals result from the pneumatolysis. In the Bodmin area the minerals formed by pneumatolytic action in the calc-flintas are axinite, hedenbergite, epidote, yellow garnet, actinolite, and another amphibole occurring in minute dark-brown needles. In the Camelford area the minerals are mainly due to contact metamorphism. The most conspicuous are yellow garnet, epidote, and idocrase, a mineral which has not hitherto been recorded from Cornwall.—A protractor for use in constructing stereographic and gnomonic projections: A. **Hutchinson**. A short historical account was given of the stereographic projection, and a protractor designed to facilitate its construction was shown. By the aid of this protractor the radii of both great circles and small circles can be readily determined. It can also be applied to the construction of the gnomonic projection, and to measuring the angles between planes and zones.—Supplementary notes on the